

Using the TPS51206EVM-745, 2-A Peak Sink/Source DDR Termination Regulator With VTTREF Buffered Reference for DDR2, DDR3, DDR3L, and DDR4

The TPS51206EVM-745 evaluation module (EVM) uses the TPS51206. The TPS51206 is a sink/source double data rate (DDR) termination regulator with VTTREF buffered reference output. It is specifically designed for low-input voltage, low cost, low external component count systems where space is a key consideration.

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1 Description

The TPS51206EVM-745 is designed to provide proper termination voltage and a 10-mA buffered reference voltage for DDR memory which covers DDR2 (0.9VTT), DDR3 (0.75VTT), DDR3L (0.675VTT) and DDR4 (0.6VTT) specifications with minimal external components.

1.1 Typical Applications

- DDR2/DDR3/DDR3L/DDR4 memory power supplies
- SSTL_18, SSTL_15, SSTL_135, and HSTL termination

1.2 Features

- VDD voltage: support 5-V rail and 3.3-V rail
- VLDOIN, VDDQ voltage range: 1.2 V–1.8 V
- Build-in, onboard transient load (with both sinking and sourcing capability) to emulate the sink/source transient behavior which helps to evaluate the dynamic performance. For ease of use, both load step and timing of transient can be modified by onboard resistors.
 - DDR2 (0.9VTT): ± 1.8 -A sink/source transient load
 - DDR3 (0.75VTT): ± 1.5 -A sink/source transient load
 - DDR3L (0.675VTT): ± 1.35 -A sink/source transient load
 - DDR4 (0.6VTT): ± 1.2 -A sink/source transient load
- Switch S1, S2 for S3 and S5 Enable function
- Convenient test points for probing VTT, VTTREF, CLK_IN and loop response testing
- Four-layer, printed-circuit board (PCB) with all the components on the bottom side

2 Electrical Performance Specifications

Table 1. TPS51206EVM-745 Electrical Performance Specifications⁽¹⁾

Parameter	Test Conditions	Min	Typ	Max	Units
Input Characteristics					
VDD voltage range			5/3.3		V
VDDQ voltage range		1.2		1.8	V
VLDOIN voltage range		VTT+0.4		3.5	V
VTT and VTTREF Termination Voltage					
DDR2 (0.9VTT)	VTT		0.9		V
	VTTREF		0.9		
DDR3 (0.75VTT)	VTT		0.75		V
	VTTREF		0.75		V
DDR3L (0.675VTT)	VTT		0.675		V
	VTTREF		0.675		V
DDR4 (0.6VTT)	VTT		0.6		V
	VTTREF		0.6		V
VTT and VTTREF Termination Current					
VTT termination current(I_{VTT})	For DDR2(0.9VTT) and DDR3(0.75VTT)	-2		2	A
	For DDR3L(0.675VTT) and DDR4(0.6VTT)	-1.5		1.5	
VTTREF termination current(I_{VTTREF})		-10		10	mA
VTT Current Limit					
VTT sink current limit		2			A
VTT source current limit		2			A

⁽¹⁾ Note: Jumpers set to default locations, See [Section 5](#) of this user's guide

Table 1. TPS51206EVM-745 Electrical Performance Specifications⁽¹⁾ (continued)

Parameter	Test Conditions	Min	Typ	Max	Units
VTT and VTTREF Termination Voltage Tolerance					
VTT termination voltage tolerance	$ I_{VTT} < 2 \text{ A}, 1.4 \text{ V} \leq V_{DDQSNS} \leq 1.8 \text{ V}$	–40		40	mV
	$ I_{VTT} < 1.5 \text{ A}, 1.2 \text{ V} \leq V_{DDQSNS} < 1.4 \text{ V}$	–40		40	mV
VTT termination voltage tolerance	$ I_{VTTREF} < 10 \text{ mA}, 1.5 \text{ V} \leq V_{DDQSNS} \leq 1.8 \text{ V}$	49%		51%	
	$ I_{VTTREF} < 10 \text{ mA}, 1.2 \text{ V} \leq V_{DDQSNS} < 1.5 \text{ V}$	48.75%		51.25%	
Operating temperature			25		°C



4 Test Setup

4.1 Test Equipment

4.1.1 Voltage Source

- **VDD:** The VDD dc Source1 must be a 0-V to 10-V variable dc source capable of supplying 1 Adc.
- **VLDOIN:** The VLDOIN DC Source2 must be a 0-V to 10-V variable dc source capable of supplying 10 Adc.

4.1.2 Meters

- V1: dc voltmeter for VDD at TP1 (VDD) and TP2 (GND)
- V2: dc voltmeter for VLDOIN at TP6 (VLDOIN) and TP7 (GND)
- V3: dc voltmeter for VTT at TP3 (VTT) and TP5 (GND)
- V4: dc voltmeter for VTTREF at TP9 (VTTREF) and TP13 (GND)

4.1.3 Load

- **LOAD:** The VTT load must be an electronic constant-current load capable of 0 A to 10 A at 0.9 Vdc

4.1.4 Oscilloscope

A digital or analog oscilloscope can be used to measure VTT sink/source current transient. The oscilloscope must be set for 1-M Ω impedance, 20-MHz bandwidth, ac coupling, 200- μ s/division horizontal resolution, 50-mV/division vertical resolution for VTT transient test. Test point TP3 (VTT) and TP5 (GND) can be used to measure VTT transient. Set horizontal cursor to measure transient load regulation.

4.2 Recommended Wire Gauge

4.2.1 VDD dc Source1 to J1

The connection between the voltage dc Source1 and J1 of the EVM can carry as much as 0.5-Adc current. The recommended wire size is AWG 18 with the total length of wire less than 4 feet (2-foot input, 2-foot return).

4.2.2 VLDOIN dc Source2 to J4

The connection between the voltage dc Source2 and J4 of the EVM can carry as much as 5-Adc current. The recommended wire size is AWG 16 with the total length of wire less than 4 feet (2-foot input, 2-foot return).

4.2.3 VTT Load to J3

The connection between the VTT load and J3 of the EVM can carry as much as 5-Adc current. The recommended wire size is AWG 16 with the total length of wire less than 4 feet (2-foot input, 2-foot return).

4.3 Recommended Test Setup

[Figure 3](#) is the recommended test setup to evaluate the TPS51206EVM-745. Working at an ESD workstation, ensure that any wrist straps, bootstraps, or mats are connected referencing the user to earth ground before power is applied to the EVM.

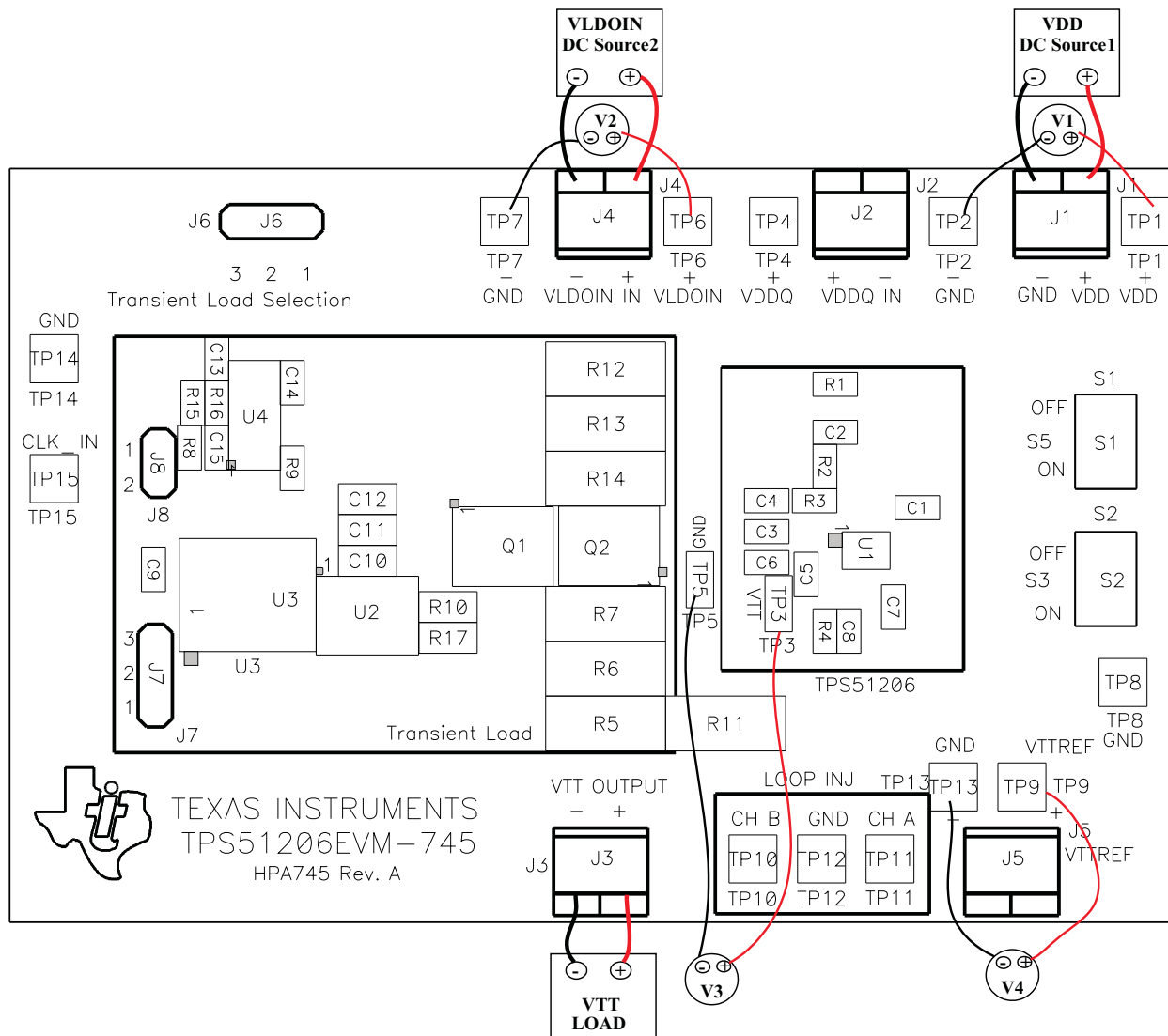


Figure 3. TPS51206EVM-745 Recommended Test Setup

5 Configurations

All jumper selections must be made prior to applying power to the EVM. Users can configure this EVM per the following configurations.

5.1 Transient Load Selection

The transient load selection can be set by J6.

Default setting: Jumper shorts on Pin2 and Pin3 of J6 to disable transient load.

Table 2. Transient Load Selection

Jumper Set to	Transient Load
1-2 pin shorted	Enable
2-3 pin shorted	Disable

5.2 Source Transient Load Selection

The source transient load selection can be set by J7.

Default setting: Jumper shorts on Pin1 and Pin2 of J7 to enable source transient load.

Table 3. Source Transient Load Selection

Jumper Set to	Transient Load
1-2 pin shorted	Enable
2-3 pin shorted	Disable

5.3 Sink Transient Load Selection

The sink transient load selection can be set by J8.

Default setting: Jumper shorts on Pin1 and Pin2 of J8 to enable sink transient load.

Table 4. Sink Transient Load Selection

Jumper Set to	Transient Load
1-2 pin shorted	Enable
No Jumper shorted	Disable

5.4 S1, S2 Enable Selection

The controller can be enabled and disabled by switch S1 and S2.

Default setting: Push S1 and S2 to the TOP (OFF position) to disable the controller.

Table 5. S3, S5 Enable Selection

S2 Switch(S3) Set to	S1 Switch(S5) Set to	VTTREF	VTT
ON position	ON position	ON	ON
OFF position	ON position	ON	OFF(High-Z)
OFF position	OFF position	OFF(Discharge)	OFF(Discharge)

6 Test Procedure

6.1 DDR2 (0.9VTT)/DDR3 (0.75VTT)/DDR3L (0.675VTT)/DDR4 (0.6VTT) Source Load Regulation

1. Ensure jumper shorts on Pin2 and Pin3 of J6.
2. Ensure jumper shorts on Pin1 and Pin2 of J7, J8.
3. Ensure switches S1 and S2 to OFF position.
4. Set VTT load to 0 A.
5. Increase VDD (VDD dc Source1) from 0 V to 5 V at J1. This is the bias supply needed for TPS51206 operation. Using V1, verify VDD voltage between 4.8 V and 5 V.
6. Increase VLDOIN voltage (VLDOIN dc Source2) from 0 V to 1.8 V for DDR2 or 1.5 V for DDR3 or 1.35 V for DDR3L or 1.2 V for DDR3L at J4. This is the LDO input. Using V2, verify VLDOIN voltage.
7. Set switches S1, S2 to ON position.
8. Use V3, V4 to measure VTT, VTTREF voltage.
9. Increase load from 0 A to 1.5 A.
10. Verify V2 and adjust VLDOIN if necessary.
11. Use V3, V4 to measure VTT, VTTREF voltage.
12. Decrease load to 0 A.
13. Set switches S1, S2 to OFF position.

6.2 DDR2 (0.9VTT)/DDR3 (0.75VTT)/DDR3L (0.675VTT)/DDR4 (0.6VTT) Sink/Source Current Transient

1. Remove VTT load from J3.
2. Remove V3 from TP3 (VTT) and TP5 (GND).
3. Add scope probe on TP3 (VTT) and TP5 (GND).
4. Remove jumper on Pin2 and Pin3 of J6 and put this jumper on Pin1 and Pin2 of J6.
5. Set switches S1, S2 to ON position.
6. TPS51206 is now operating at sink/source load transient.
7. Verify V2 and adjust VLDOIN if necessary.
8. Use scope probe at TP3 (VTT) and TP5 (GND) to monitor VTT load transient operation, and use cursor to make measurement. The waveform is shown in [Section 7.4](#).
9. Set switch S1, S2 to OFF position.
10. Decrease dc source 1.2 V to 0 V.

6.3 DDR2 (0.9VTT)/DDR3 (0.75VTT)/DDR3L (0.675VTT)/DDR4 (0.6VTT) Loop Stability Measurement

TPS51206EVM-745 contains an R4 (10-Ω) series resistor in the feedback loop for loop response analysis.

1. Set up EVM as described in [Section 4](#) and [Figure 3](#).
2. Connect isolation transformer to test points marked TP11 and TP10.
3. Connect input signal amplitude measurement probe (channel A) to TP11. Connect output signal amplitude measurement probe (channel B) to TP10.
4. Connect ground lead of channel A and channel B to TP12.
5. Inject approximately 50-mV or less signal through the isolation transformer.
6. Sweep the frequency from 1 kHz to 1 MHz with 10-Hz or lower post filter. The control loop gain and phase margin can be measured.
7. Disconnect isolation transformer from bode plot test points before making other measurements. Signal injection into feedback may interfere with accuracy of other measurements.

6.4 List of Test Points

Table 6. Functions of Each Test Point

Test Points	Name	Description
TP1	VDD	Device power supply input (3.3 V or 5 V)
TP2	GND	Ground
TP3	VTT	VTT Output
TP4	VDDQ	VDDQSNS sense input, when VLDOIN is different from VDDQSNS voltage
TP5	GND	Ground
TP6	VLDOIN	Power supply input for VTT/VTTREF
TP7	GND	Ground
TP8	GND	Ground
TP9	VTTREF	VTTREF buffered reference output
TP10	CHB	Input B for loop injection
TP11	CHA	Input A for loop injection
TP12	GND	Ground
TP13	GND	Ground
TP14	GND	Ground
TP15	CLK_IN	Sink/source load transient timing signal

6.5 Equipment Shutdown

1. Shut down VDD dc Source1 and VLDOIN dc Source2
2. Shut down VTT load.
3. Shut down oscilloscope.

7 Performance Data and Typical Characteristic Curves

7.1 VTT Load Regulation

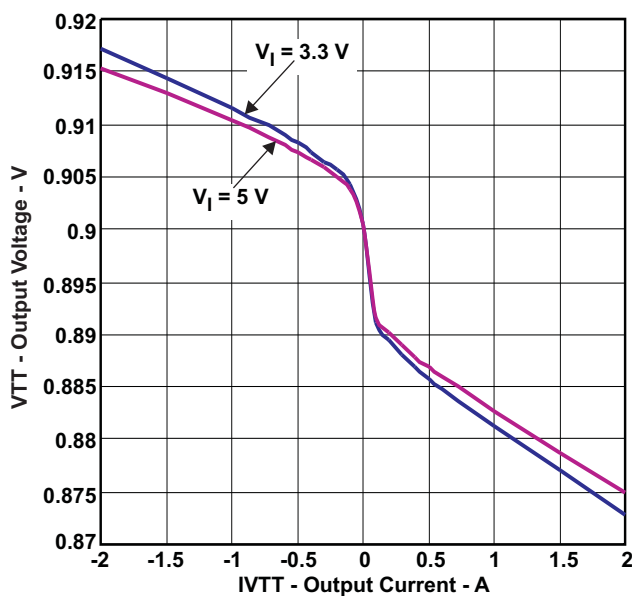


Figure 4. DDR2(0.9VTT) Load Regulation

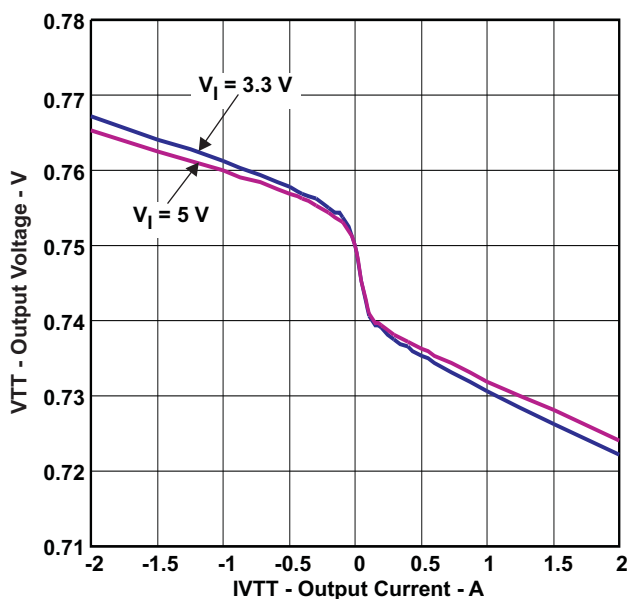


Figure 5. DDR3 (0.75VTT) Load Regulation

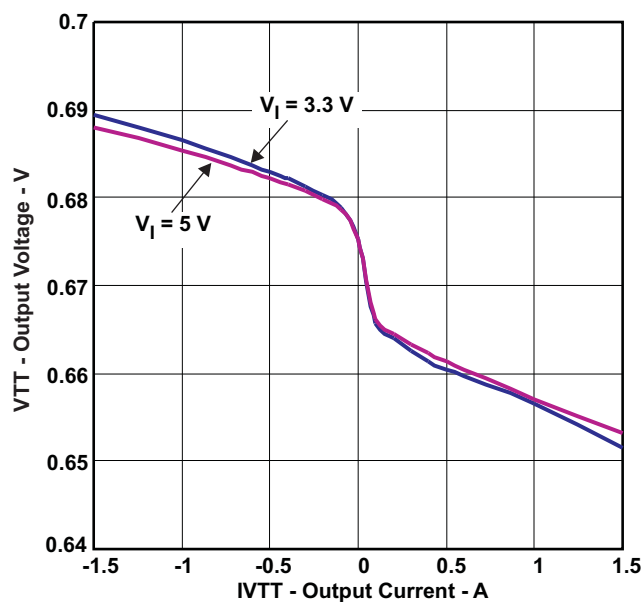


Figure 6. DDR3L (0.675VTT) Load Regulation

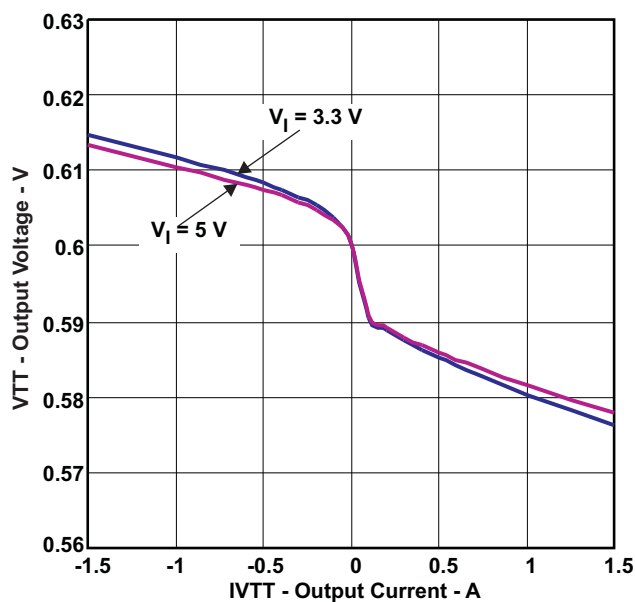


Figure 7. DDR4 (0.6VTT) Load Regulation

7.2 VTTREF Load Regulation

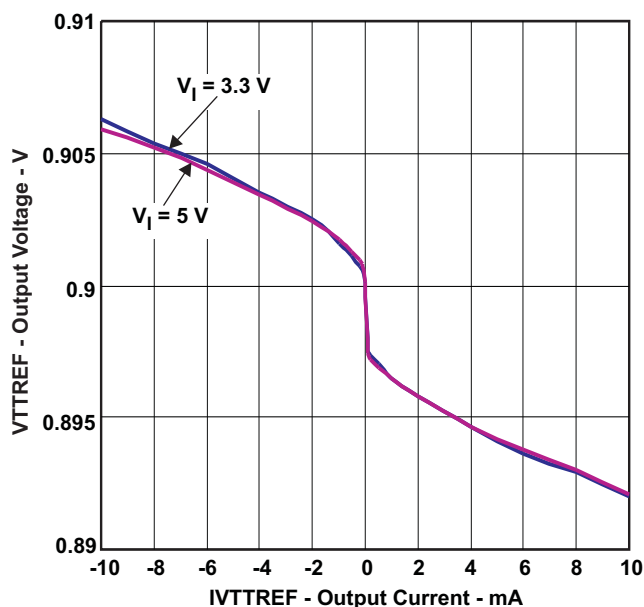


Figure 8. DDR2 (0.9VTTREF) Load Regulation

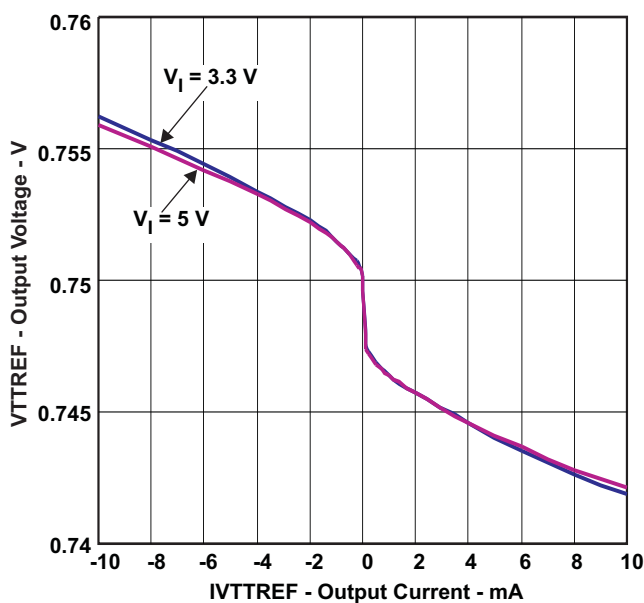


Figure 9. DDR3 (0.75VTTREF) Load Regulation

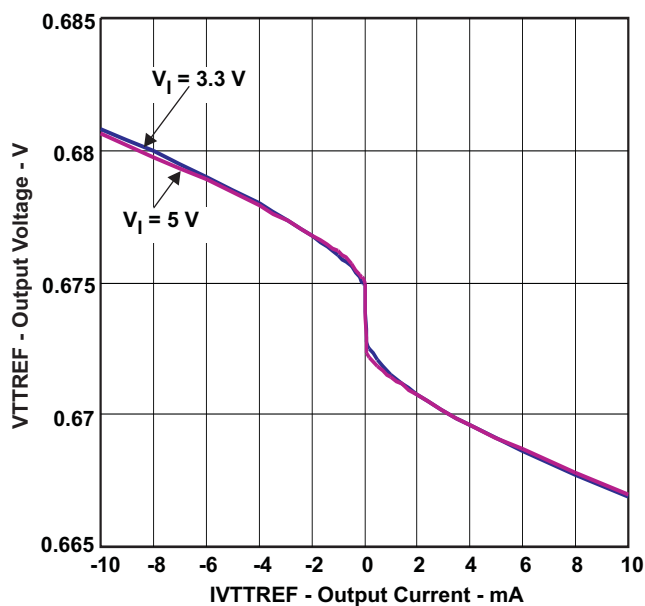


Figure 10. DDR3L (0.675VTTREF) Load Regulation

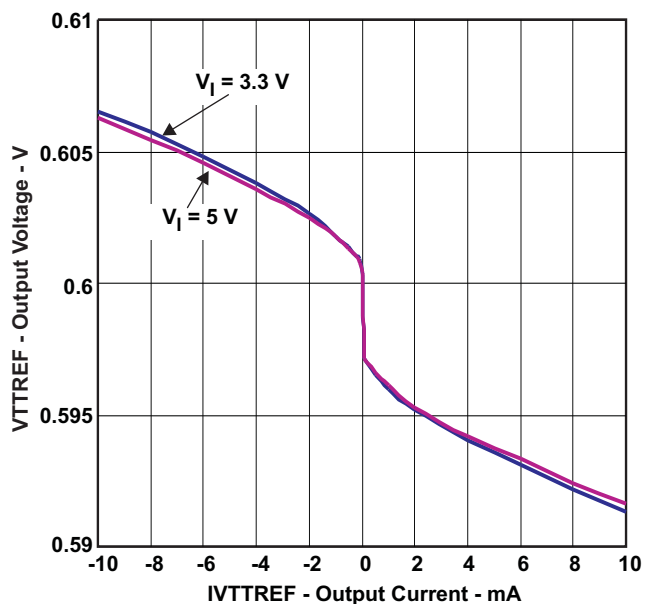


Figure 11. DDR4 (0.6VTTREF) Load Regulation

7.3 VTT Dropout Voltage

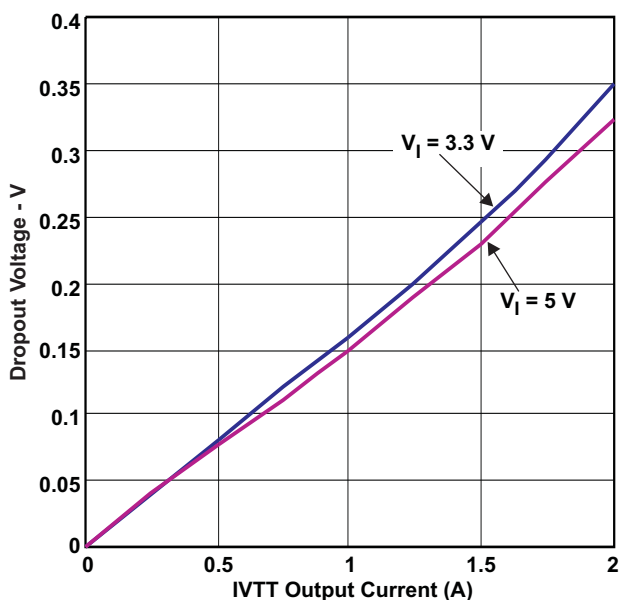


Figure 12. DDR2 (0.9VTT) Dropout Voltage

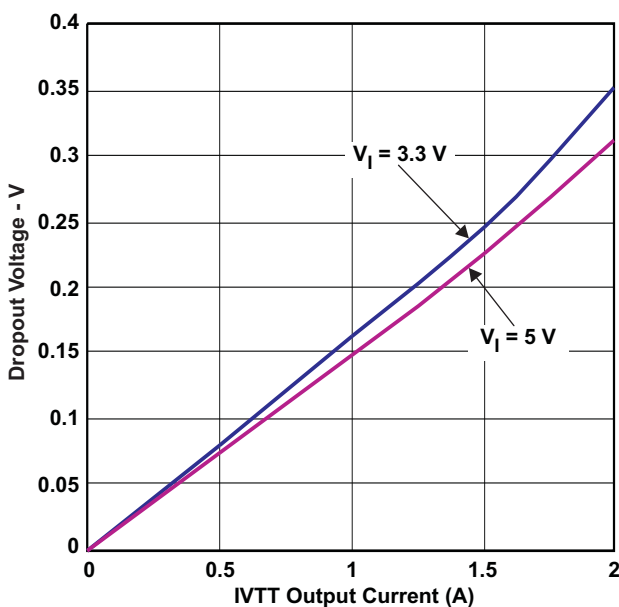


Figure 13. DDR3 (0.75VTT) Dropout Voltage

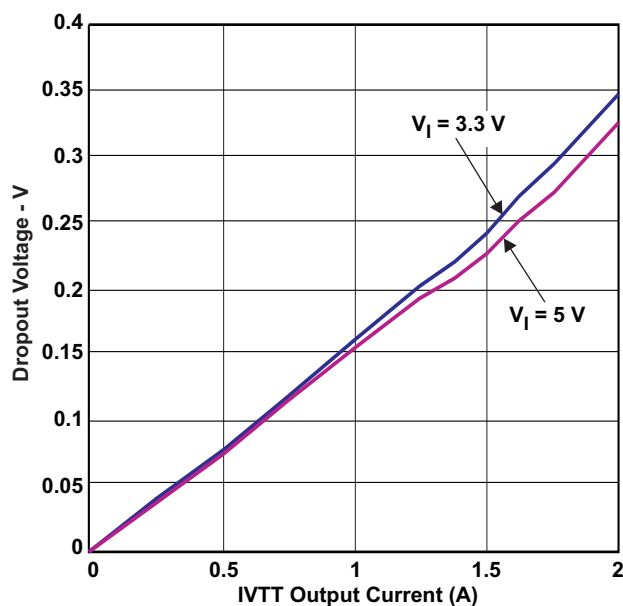


Figure 14. DDR3L (0.675VTT) Dropout Voltage

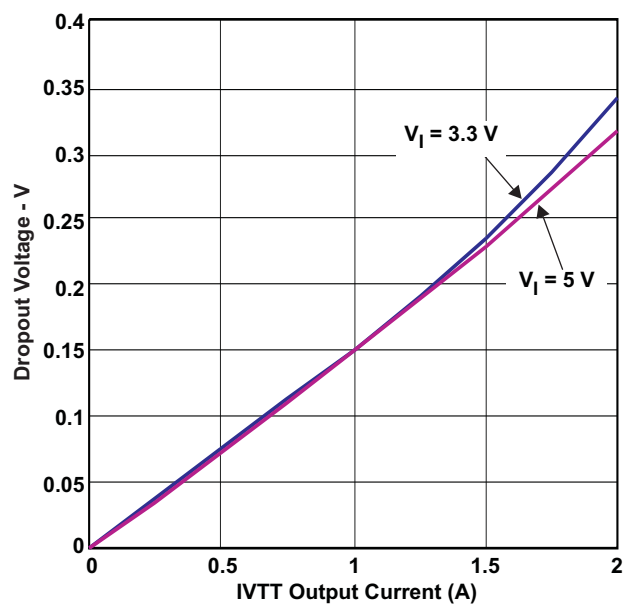


Figure 15. DDR4 (0.6VTT) Dropout Voltage

7.4 VTT Sink/Source Load Transient

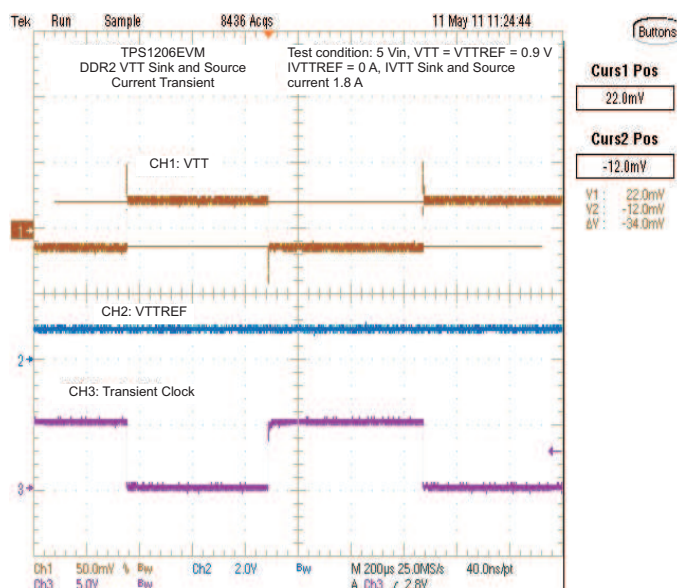


Figure 16. DDR2 (0.9VTT) 1.8-A Sink/Source

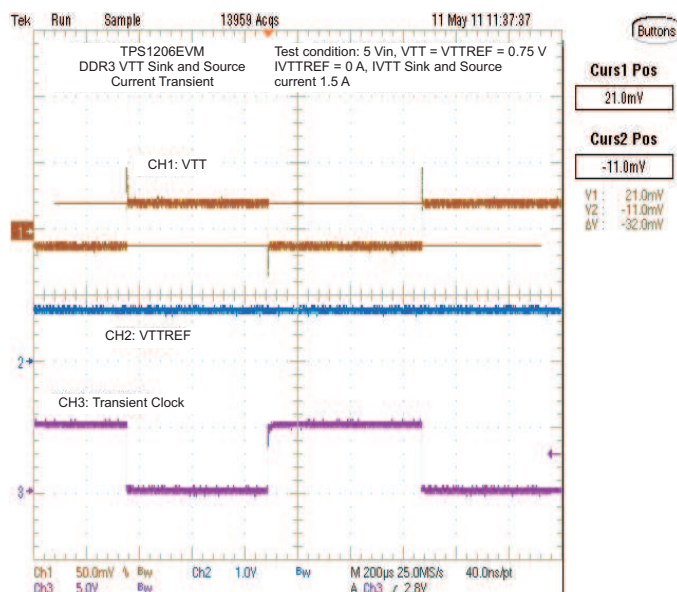


Figure 17. DDR3 (0.75VTT) 1.5-A Sink/Source

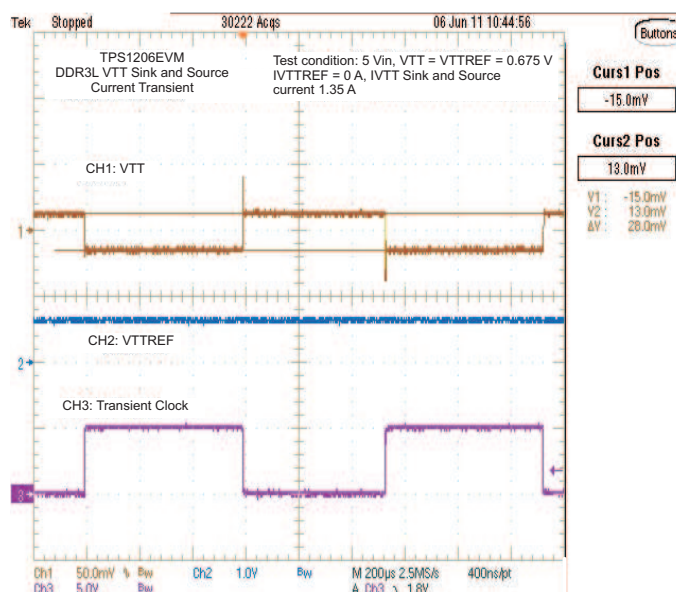


Figure 18. DDR3L (0.75VTT) 1.35-A Sink/Source

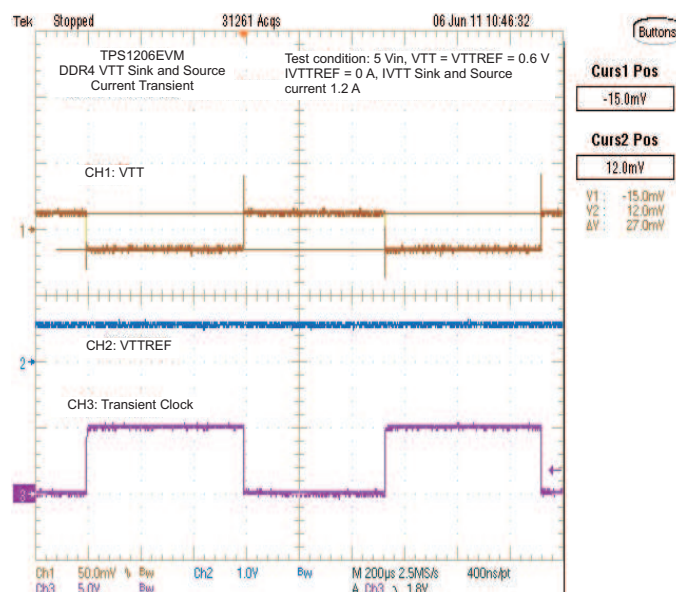


Figure 19. DDR4 (0.6VTT) 1.2-A Sink/Source

7.5 DDR3(0.75VTT) S5 Enable Turnon/Turnoff

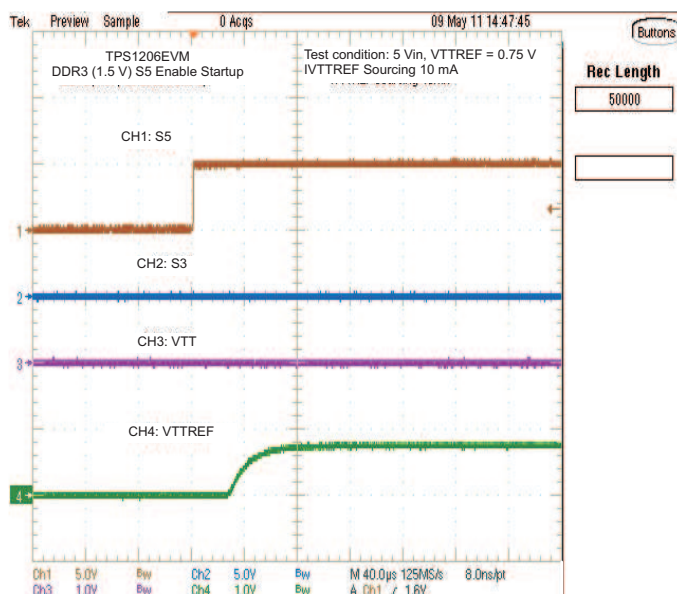


Figure 20. DDR3 (0.75VTT) S5 Enable Turnon

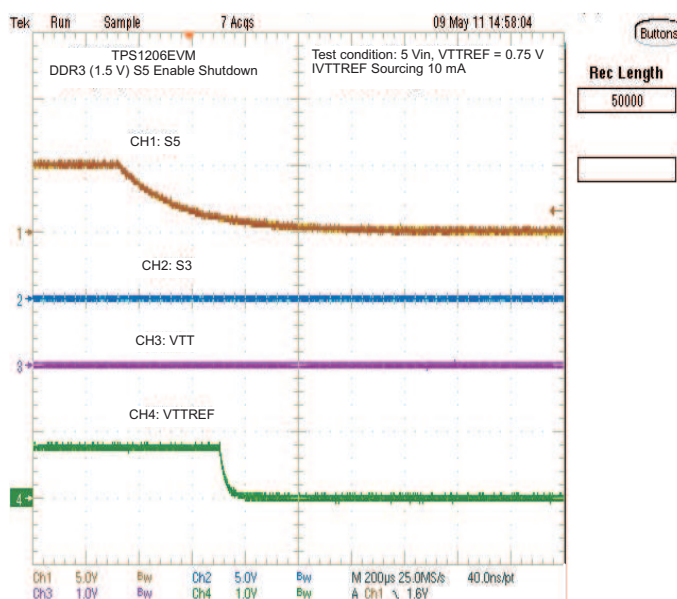


Figure 21. DDR3 (0.75VTT) S5 Enable Turnoff

7.6 DDR3 (0.75VTT) S3 Enable Turnon/Turnoff

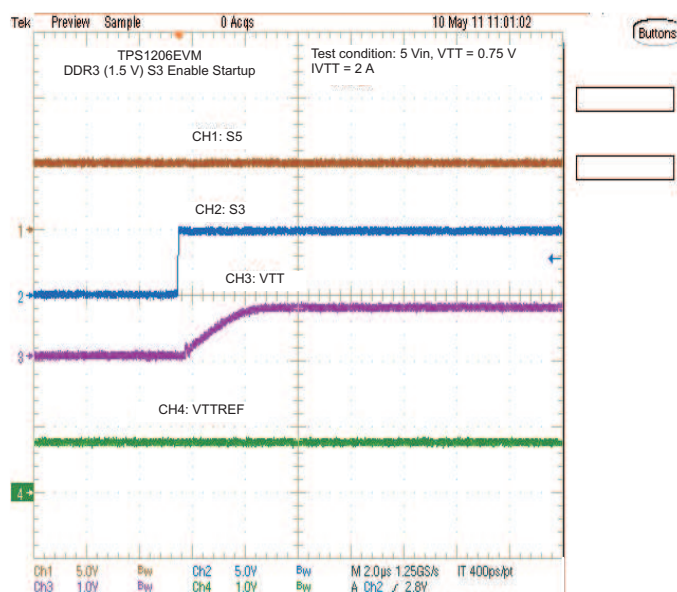


Figure 22. DDR3 (0.75VTT) S3 Enable Turnon

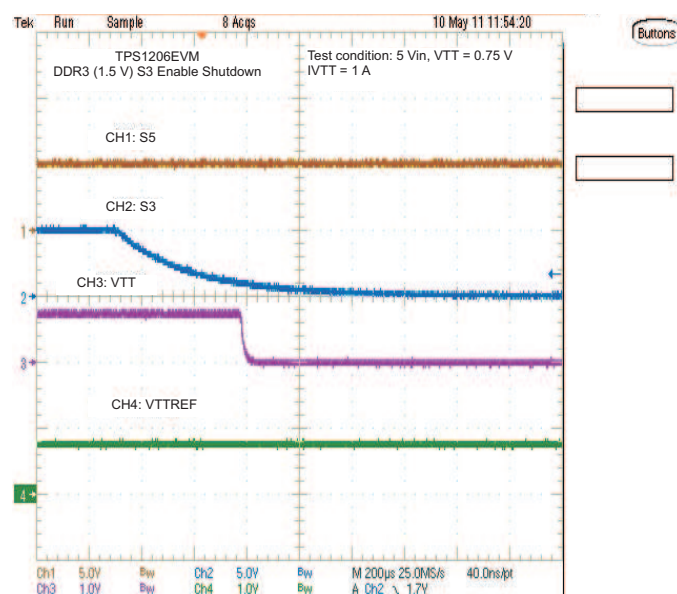
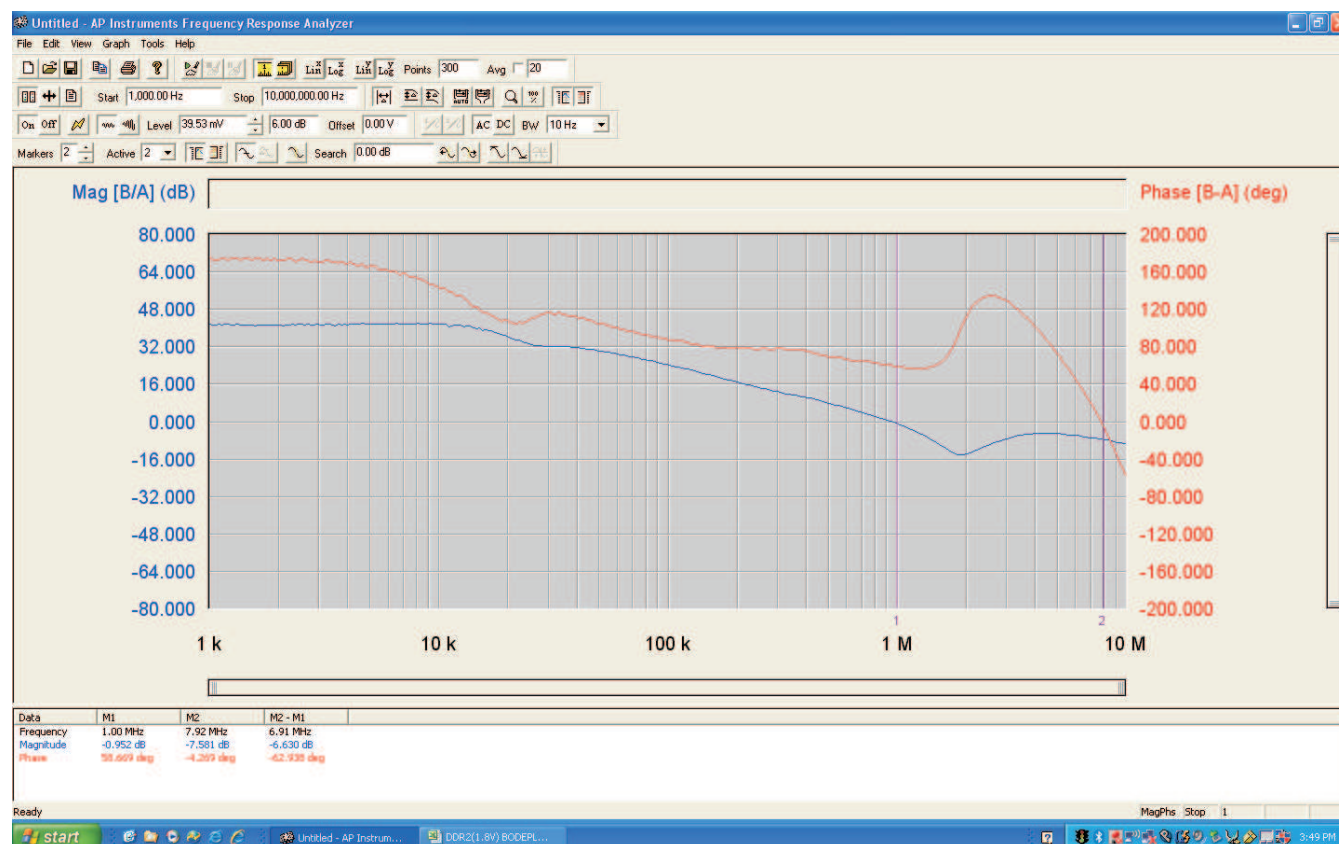


Figure 23. DDR3 (0.75VTT) S3 Enable Turnoff

7.7 DDR3 (0.75V_{TT}) Bode Plot



Test condition: 5 Vin, VLDOIN = VDDQ = 1.5 V, VTT = VTTREF = 0.75 V, I_{VTT} = 2 A Source Current
Phase Margin: 58.7Deg, **Gain Margin:** 7.6dB, **Crossover Frequency:** 1MHz

Figure 24. DDR3 Bode plot

8 EVM Assembly Drawing and PCB Layout

Figure 25 through Figure 30 show the design of the TPS51206EVM-745 printed-circuit board. The EVM has been designed using a four-layer, 2-oz copper, printed-circuit board.

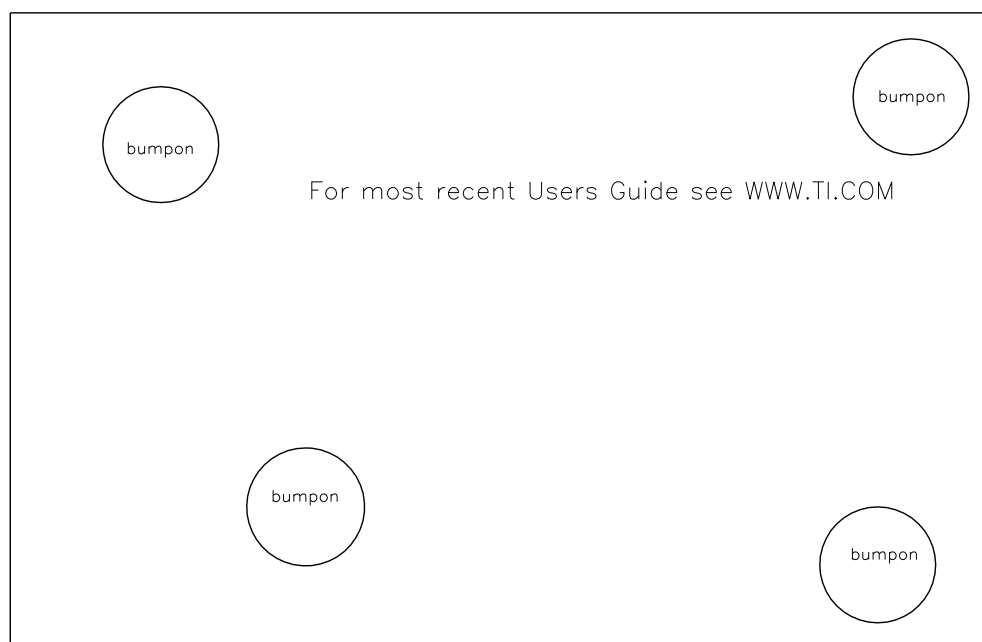


Figure 25. TPS51206EVM-745 Top Layer Assembly Drawing

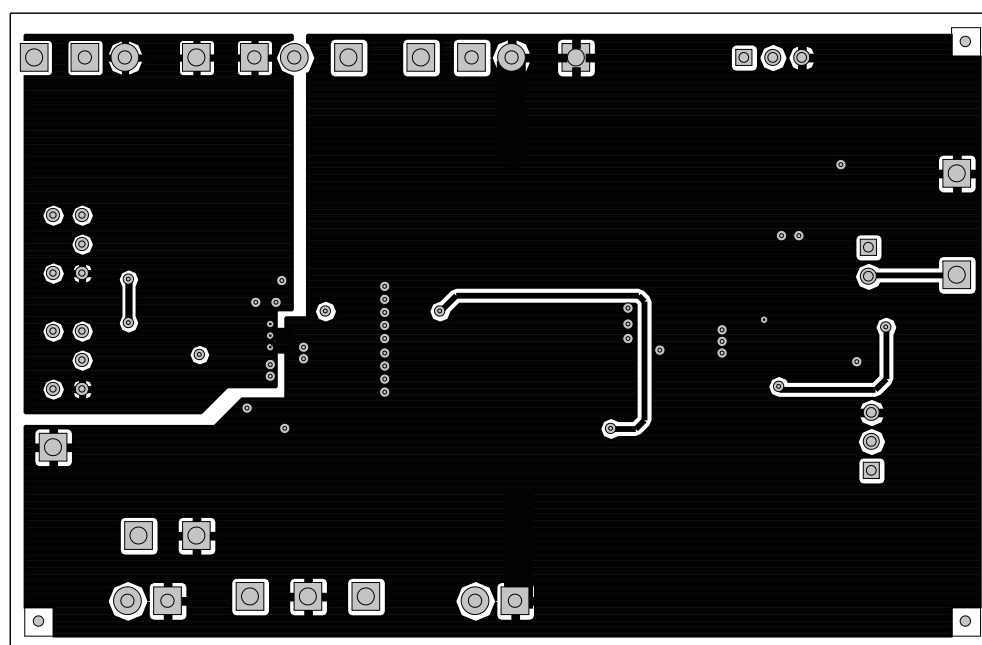


Figure 26. TPS51206EVM-745 Top Layer

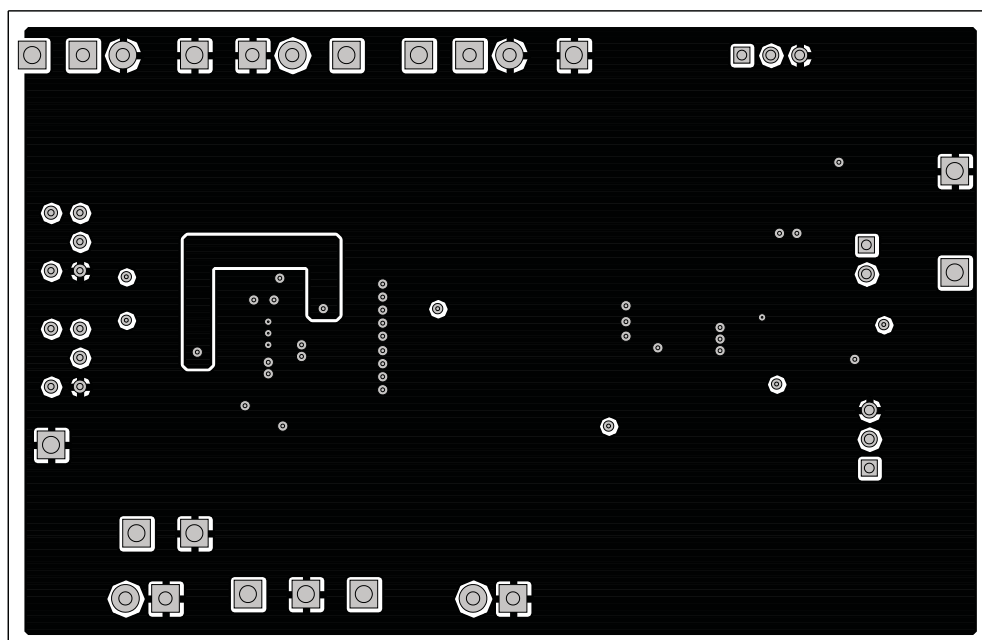


Figure 27. TPS51206EVM-745 Internal Layer 1

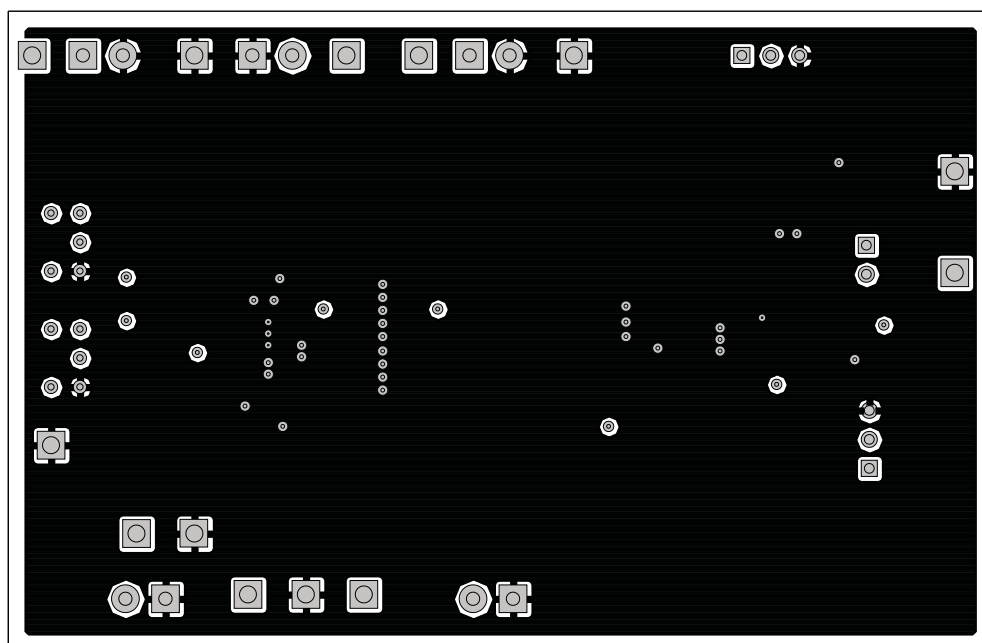


Figure 28. TPS51206EVM-745 Internal Layer 2

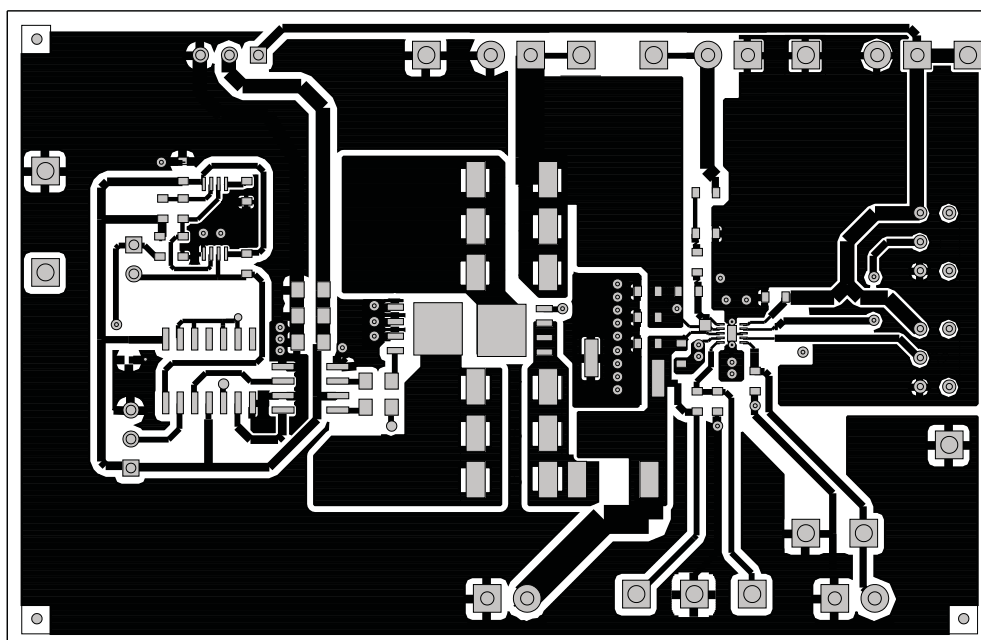


Figure 29. TPS51206EVM-745 Bottom Layer

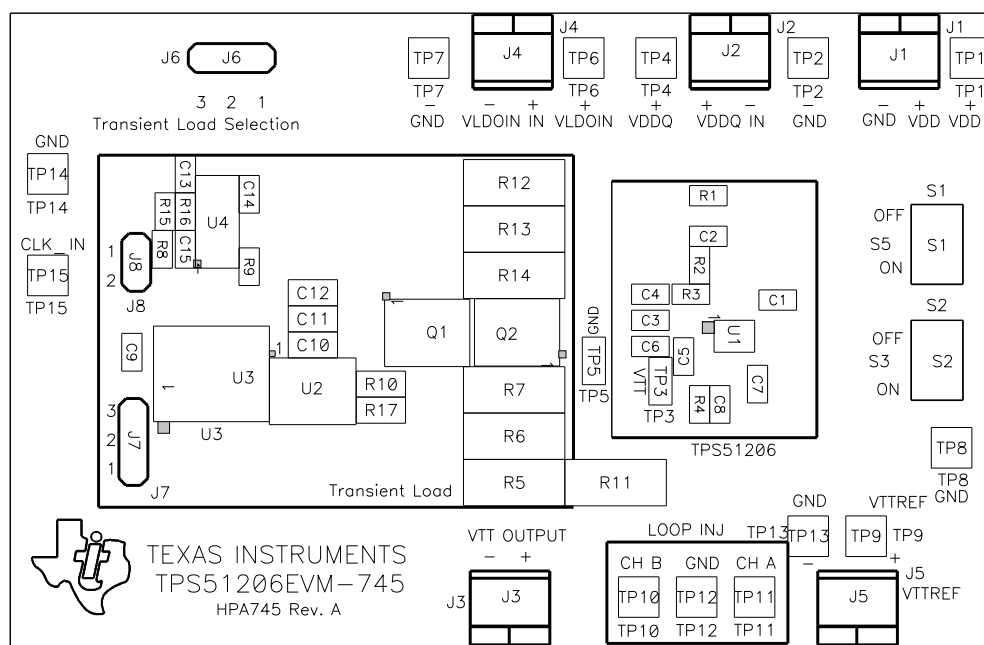


Figure 30. TPS51206EVM-745 Bottom Layer Assembly

9 Bill of Materials

Table 7 provides the EVM components list according to the schematics shown in Figure 1 and Figure 2.

Table 7. Bill of Materials

QTY	RefDes	Description	MFR	Part Number
3	C1, C14, C15	Capacitor, Ceramic, 0.1 μ F, 10V, X7R, 20%, 0603	STD	STD
3	C10, C11, C12	Capacitor, Ceramic, 10 μ F, 10V, X5R, 20%, 0805	STD	STD
3	C3, C4, C5	Capacitor, Ceramic, 10 μ F, 10V, X5R, 20%, 0603	STD	STD
1	C7	Capacitor, Ceramic, 0.22 μ F, 10V, X7R, 20%, 0603	STD	STD
2	C9, C13	Capacitor, Ceramic, 1 μ F, 10V, X7R, 20%, 0603	STD	STD
2	Q1, Q2	MOSFET, Nch, 25V, 31A, 2.5m Ω	TI	CSD16407Q5
2	R10, R17	Resistor, Chip, 100, 1/10W, 5%, 0805	STD	STD
1	R11	Resistor, Chip, 0, 1W, 5%, 2512	STD	STD
1	R15	Resistor, Chip, 1.00k, 1/16W, 1%, 0603	STD	STD
1	R16	Resistor, Chip, 7.50k, 1/16W, 1%, 0603	STD	STD
1	R3	Resistor, Chip, 0, 1/16W, 5%, 0603	STD	STD
1	R4	Resistor, Chip, 10, 1/16W, 5%, 0603	STD	STD
6	R5, R6, R7, R12, R13, R14	Resistor, Chip, 1.5, 1W, 5%, 2512	STD	STD
2	R8, R9	Resistor, Chip, 100k, 1/16W, 1%, 0603	STD	STD
1	U1	IC, 2A Peak sink/source DDR termination regulator	TI	TPS51206DSQ
1	U2	IC, Dual, 4A high speed low side power MOSFET drivers	TI	UCC27325D
1	U3	IC, Quad, 2-Input Positive NAND Gates	TI	SN74AHCT00D
1	U4	IC, Precision Timer	TI	NE555PW

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It is important to operate this EVM within the input voltage range of 0 V to 5.5 V and the output voltage range of 0.6 V to 1.8 V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

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During normal operation, some circuit components may have case temperatures greater than 50°C. The EVM is designed to operate properly with certain components above 50°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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